



SEWERABLE WATER MONITORING

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Introduction

In 2001, the Livermore site discharged an average of 0.88 million liters (ML) per day of wastewater to the City of Livermore sewer system, an amount that constituted 4.0% of the total flow to the system. This volume includes wastewater generated by Sandia National Laboratories/California, which is discharged to the LLNL collection system and combines with LLNL sewage before it is released at a single point to the municipal collection system ([Figure 6-1](#)).

In 2001, Sandia/California generated approximately 12% of the total effluent discharged from the Livermore site. LLNL's wastewater contains sanitary sewage and industrial wastewater and is discharged in accordance with permit requirements and the City of Livermore Municipal Code, as discussed below in the [“Pretreatment Discharges”](#) and [“Categorical Discharges”](#) sections.

The effluent is treated at the Livermore Water Reclamation Plant (LWRP), which is part of the Livermore-Amador Valley Wastewater Management Agency. The treated sanitary wastewater is transported out of the valley through a pipeline and discharged into San Francisco Bay. A small portion (~20%) of this treated wastewater is used for fire suppression and summer irrigation of the municipal golf course adjacent to the LWRP.

LLNL receives water from two suppliers. LLNL's primary water source is the Hetch-Hetchy Aqueduct. Secondary or emergency water deliveries are taken from the Alameda County Flood Control and Water Conservation District Zone 7. This water is a mixture of groundwater and water from the South Bay Aqueduct of the State Water Project. Water quality parameters for the two sources are obtained from the suppliers and are used to evaluate compliance with the discharge permit conditions that limit changes in water quality between receipt and discharge.



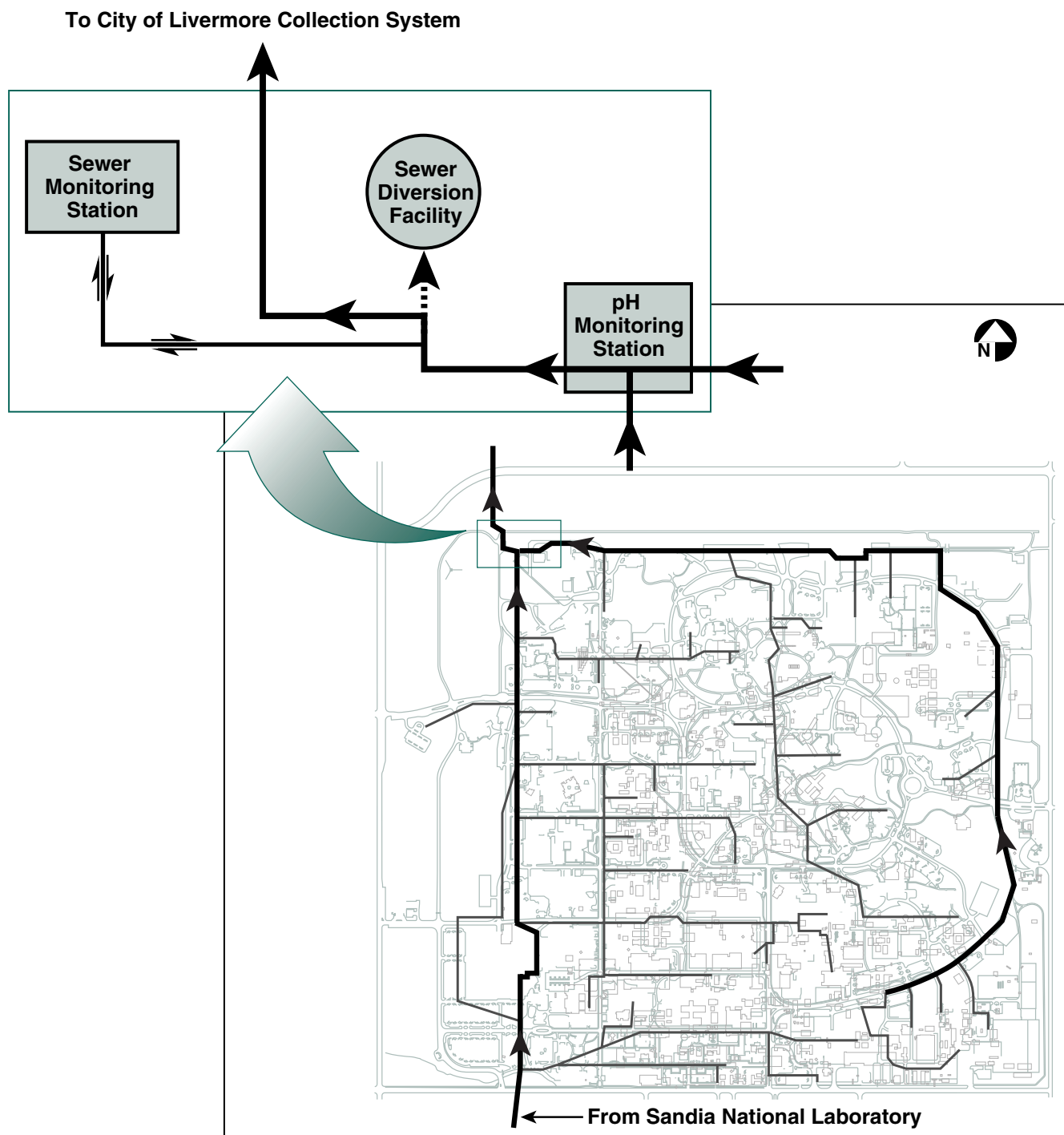


Figure 6-1. LLNL sanitary sewer system, monitoring stations, and diversion facility

Preventive Measures

Administrative and engineering controls at the Livermore site are designed to prevent potentially contaminated wastewater from being discharged directly to the sanitary sewer. Waste generators receive training on proper waste handling. LLNL Environmental Protection Department (EPD) personnel review facility procedures and inspect processes to ensure appropriate discharges. Retention tanks collect wastewater from processes that might release contaminants in quantities sufficient to violate permit conditions or disrupt operations at the LWRP. Wastewater that cannot be discharged into one or more of the surface water collection units at LLNL's Experimental Test Site (Site 300) is transported to LLNL's Livermore site and managed under Livermore site retention tank administrative controls. Groundwater (generated from startup operations associated with new, portable groundwater treatment units, tests of experimental treatment units, and maintenance of existing treatment facilities) is analyzed for pollutants of concern and must meet permitted criteria, or LWRP approval must be obtained before it can be discharged to the sanitary sewer. Finally, to verify the success of training and control equipment, wastewater is sampled and analyzed not only at the significant points of generation, as defined by type and quantity of contaminant generated, but also at the point of discharge to the municipal sewer system.

For facilities with installed retention tank systems, collected wastewater is discharged to the sanitary sewer only if analytical laboratory results show that pollutant levels are within allowable limits (Grandfield 1989). LLNL has developed internal guidelines to ensure that sewer effluent for the entire site complies with LLNL's wastewater discharge permit. The process of wastewater generation and discharge frequency from retention tanks varies over time, depending upon the process.

During 2001, there were approximately 33 waste retention tank systems in use at the Livermore site, with an average of 13 wastewater retention tanks discharged each month, averaging a volume of 8660 L per tank.

Processes that discharge to the sanitary sewer are subject to the general pretreatment self-monitoring program specified in the Wastewater Discharge Permit issued by the LWRP and, as such, are managed by LLNL using guidelines as applied at the point of discharge into the LLNL sewer.

If pollutant levels exceed concentrations that would result in a violation of LLNL's LWRP permit, the wastewater is either treated to reduce pollutants to levels that preclude a permit violation, or it is shipped to an off-site treatment or disposal facility. Liquids containing radioactivity are handled on site and may be treated using processes that reduce the activity to levels well below those required by DOE Order 5400.5, or they are shipped to an off-site treatment or disposal facility.

For the year as a whole, the monitoring data reflect the success of LLNL's discharge control program in preventing any adverse impact on the operations of Livermore's treatment plant and are consistent with past values.

Monitoring

Monitoring at the Sewer Monitoring Station

LLNL's sanitary sewer discharge permit requires continuous monitoring of the effluent flow rate and pH. Samplers collect flow-proportional composite samples and instantaneous grab samples that are analyzed for metals, radioactivity, toxic chemicals, and water-quality parameters. In addition, as a best management practice, the outflow to the municipal collection system is sampled continuously and analyzed in real time for conditions that might upset the LWRP treatment



process or otherwise impact the public welfare. The effluent is continuously analyzed for pH, regulated metals, and radioactivity. If concentrations above warning levels are detected, an alarm is registered at the LLNL Fire Dispatcher's Station, which is attended 24 hours a day, and the site effluent is diverted to the Sewer Diversion Facility (SDF). The monitoring system provides a continuous check on sewage control, and the LWRP is notified of contaminant alarms. Trained staff respond to all alarms to evaluate the cause and take appropriate action.

Monitoring at the Upstream pH Monitoring Station

In addition to the continuous monitoring at the Sewer Monitoring Station (SMS), LLNL monitors pH at the upstream pH Monitoring Station (pHMS) (see [Figure 6-1](#) for a system diagram). The pHMS continuously monitors pH between 7 a.m. and 7 p.m. during the workweek and diverts pH discharges outside the permitted 5-to-10 range to the SDF. The pHMS duplicates the pH monitoring and diversion capabilities of the SMS, but because it is located upstream of the SDF it is able to initiate diversion earlier. Earlier detection allows LLNL to divert all of the unpermitted site effluent detected by the pHMS.

Diversion System

LLNL operates and maintains a diversion system that activates automatically when either the SMS continuous monitoring system or the pHMS sounds an alarm. For SMS-activated alarms, the SDF ensures that all but the first few minutes of the potentially affected wastewater flow is retained at LLNL, thereby protecting the LWRP and minimizing any required cleanup. When the SDF is activated by the pHMS for pH excursions, even the first few minutes of affected wastewater flow are retained. Up to 775,000 L of potentially contaminated sewage can be held pending analysis to

determine the appropriate handling method. The diverted effluent may be returned to the sanitary sewer (if it meets LLNL's wastewater discharge permit limits), shipped for off-site disposal, or treated at LLNL's Hazardous Waste Management (HWM) Facility. All the diverted sewage in 2001 was returned to the sanitary sewer.

Pretreatment Discharges

The general pretreatment regulations establish both general and specific standards for the discharge of prohibited substances that apply to all industrial users (40 CFR 403.5). These regulations apply even if LLNL is subject to other federal, state, or local pretreatment standards. The pretreatment standards contain prohibitions intended to protect the LWRP and its operations from interference with its treatment processes or pass-through that would cause the LWRP to violate its own effluent limitations. The LWRP, under the authorization of the San Francisco Bay Regional Water Quality Control Board (SFBRWQCB), requires self-monitored pretreatment programs at both the Livermore site and Site 300. The sampling and monitoring of nondomestic, industrial sources covered by pretreatment standards defined in 40 CFR 403 are required in the 2001-2002 Wastewater Discharge Permit No. 1250 issued for the discharge of wastewater from LLNL into the City of Livermore sewer system.

Permit 1250 lists all the self-monitoring parameters that are applied at the SMS before wastewater enters the municipal collection system at LLNL's effluent outfall (see [Figure 6-1](#)). Parameters with numerical limits are listed in [Table 6-1](#). The additional discharge limits shown in [Table 6-1](#) are discussed in the "[Categorical Discharges](#)" and "[Discharges of Treated Groundwater](#)" sections. Other required parameters such as flow rate, biological oxygen demand, total dissolved solids,

Table 6-1. Permit discharge limits for nonradioactive pollutants in LLNL wastewaters

Parameter	Permit discharge limits			
	Permit 1250			Permit 1510G
	Outfall ^(a)	Metal finishing ^(b)	Electric component ^(b)	Treated groundwater
Metals (mg/L)				
Arsenic	0.06	— ^(c)	0.83	0.06
Cadmium	0.14	0.07	— ^(c)	0.14
Chromium (total)	0.62	1.71	— ^(c)	0.62
Copper	1.0	2.07	— ^(c)	1.00
Lead	0.20	0.43	— ^(c)	0.20
Mercury	0.01	— ^(c)	— ^(c)	0.01
Nickel	0.61	2.38	— ^(c)	0.61
Silver	0.20	0.24	— ^(c)	0.20
Zinc	3.0	1.48	— ^(c)	3.00
Organics (mg/L)				
TTO ^(d)	1.00	2.13	1.37	1.00
Other (mg/L)				
Cyanide ^(e)	0.04	0.65	— ^(c)	0.04 ^(f)
Oil and grease	100	— ^(c)	— ^(c)	— ^(g)
pH (pH units)	5–10	— ^(c)	— ^(c)	5–10

a These standards apply at the SMS (the point of discharge to the municipal sewer). All other standards in this table apply at the point of discharge into LLNL's sanitary sewer system.

b Values shown for these categorical standards were specified by EPA. By regulation, the EPA or City of Livermore limit is used, whichever is lower. The internal limits in [Table 6-1](#) are applied by LLNL where no other standard is specified.

c There is no specific categorical limit for this parameter; therefore, the [Table 6-1](#) internal discharge limits apply.

d Total toxic organics (TTO) is defined by the Livermore Municipal Code as the sum total of all detectable organic compounds that are on EPA's current priority pollutant list and that are present in concentrations of 0.01 mg/L or greater. Analysis using EPA Methods 624 and 625 satisfies this requirement. A listing of the specific compounds included may be found in the Data Supplement, Chapter 6.

e Limits apply to cyanide discharges other than cyanide salts. Cyanide salts are classified by the State of California as "extremely hazardous waste" and cannot be discharged to the sewer.

f Although Permit 1510G lists a discharge limit for cyanide, sample collection is not required by the self-monitoring program.

g Permit 1510G does not list a discharge limit for oil and grease.



total suspended solids, and tributyltin are also monitored at the SMS but have no specific numerical limits.

In 2001, LLNL only received one Notice of Violation (NOV) from the LWRP for exceeding permit limits in 2001. (LLNL received one NOV from the LWRP in early 2001 for a discharge of chromium and nickel in 2000 that exceeded permit limits.) The only effluent discharge limit for wastewater that was exceeded was the discharge limit for lead.

Categorical Discharges

The Environmental Protection Agency (EPA) publishes categorical standards as regulations separate from the general pretreatment regulations and developed for broad categories of specific industrial processes determined to be the most significant contributors to point-source water pollution. These standards contain specific numerical limits for the discharge of industry-specific pollutants from individual processes. The number of processes at LLNL using these pollutants is subject to change as programmatic requirements dictate. During 2001, the LWRP identified 14 specific LLNL wastewater-generating processes that fall under the definition of two categorical standards: Electrical and Electronic Components (40 CFR 469), and Metal Finishing (40 CFR 433). The discharge limits for these standards are shown in [Table 6-1](#). Under the terms in Permit 1250, only those processes that discharge to the sanitary sewer require sampling, inspection, and reporting. Three of the 14 identified processes meet these criteria. In 2001, LLNL analyzed samples for all regulated parameters from these three processes and demonstrated compliance with all Federal Categorical Discharge limits.

The first of the three categorical processes that discharge directly into the sanitary sewer system is an abrasive jet machine (or water-jet) that is

regulated under the Metal-Finishing Point Source Category; the filtered water from this process is discharged to the sanitary sewer. In January 2001, LLNL received a Notice of Violation from the LWRP for discharges from this process on November 2, 2000. The LWRP conducted a corrective action review and determined that no fines or penalties were required. This event was fully described in Table 2-7 in the *LLNL Environmental Report 2000*.

The other two discharging categorical processes are both regulated under the Federal Electrical and Electronic Component Point Source Category. One is a series of processes clustered within a single building that houses research-scale microfabrication laboratories used for developing prototype semiconductor devices. These laboratories discharge into a building wastewater retention system, and because they are housed within the same building with no diluting flow, they share a single point of compliance. The other categorical process is a small gallium arsenide cutting operation; this process discharges directly to the sanitary sewer.

The nondischarging processes, all regulated under the Metal-Finishing Point Source Category (40 CFR 433), were printed circuit board manufacturing, electrolysis plating, chemical etching, electroplating, anodizing, coating, electrical discharge machining, and abrasive jet machining (water-jet). The wastewater from these processes was contained for removal and off-site shipment by LLNL's HWM Division.

Discharges of Treated Groundwater

LLNL's groundwater discharge permit (1510G 2001) allows treated groundwater from site-wide cleanup activities under the Comprehensive Environmental Response, Compensation and Liability

Act (CERCLA) of 1980 to be discharged to the City of Livermore sanitary sewer in compliance with [Table 6-1](#) effluent limitations taken from the Livermore Municipal Code.

During 2001, the volume of groundwater discharged to the sanitary sewer was approximately 30,945 L. Two groundwater discharges occurred during 2001. The first was related to well purging and maintenance of an existing treatment facility (TFD); the second contained groundwater from the lower zone, discharged directly to the sanitary sewer during an off-site pump test (well W-1701). Both events were separately sampled and discharged to the sewer in 2001, all in compliance with self-monitoring permit provisions and discharge limits of Permit 1510G. Monitoring data are presented in the [Data Supplement, Chapter 6](#).

Radioactive Pollutants in Sewage Monitoring Results

LLNL determines the total radioactivity released from tritium, alpha emitters, and beta emitters based either on the measured radioactivity in the effluent or on the limit of sensitivity, whichever is higher (see [Table 6-2](#)). The 2001 combined releases of alpha and beta sources was 0.32 GBq (0.0086 Ci). The combined total is based on the alpha and beta results shown in [Table 6-2](#). The tritium total was 4.9 GBq (0.13 Ci), and the annual mean concentration of tritium in LLNL sanitary sewer effluent was 0.014 Bq/mL (0.38 pCi/mL).

Summary results for tritium measured in the sanitary sewer effluent from LLNL and LWRP are presented in [Table 6-3](#).

The monthly tritium numbers are based on the flow-weighted average of the individual daily sample results for a given month. The total annual result is based on the multiplication of each daily

Table 6-2. Estimated total radioactivity in LLNL sanitary sewer effluent, 2001

Radioactive emitter	Estimate based on effluent activity (GBq) ^(a)	Limit of sensitivity (GBq)
Tritium	4.9	3.3
Alpha sources	0.061	0.034
Beta sources	0.262	0.040

^a 37 GBq = 3.7×10^{10} Bq = 1 Ci

sample result or the limit of sensitivity, whichever is greater, by the total flow volume over which the sample was collected, and summing up over all samples. (All other total annual results presented in this chapter for radioactive emitters are also calculated conservatively; the limit of sensitivity or minimum detectable concentration is used to determine the total annual activity when the limit of sensitivity is greater than the sample result.) Also included in the table are fractions of LWRP, Department of Energy (DOE), and 10 CFR 20 limits, which are discussed in the “[Environmental Impact](#)” section of this chapter.

The historical trend in the monthly average concentration of tritium is shown in [Figure 6-2](#). Also included in the figure are the limit of sensitivity (LOS) values for the tritium analysis and the DOE tritium limit (370 Bq/mL), which are discussed in the “[Environmental Impact](#)” section. The trend indicates a well-controlled tritium discharge, orders of magnitude below the DOE tritium limit. (Note that for 2000–2001 data, only results above the LOS are plotted.)

The concentrations of plutonium-239 and cesium-137 measured in the sanitary sewer effluent from LLNL and LWRP are presented in [Table 6-4](#). The plutonium and cesium numbers are the direct results of analyses of monthly composite samples of LLNL and LWRP effluent, and quarterly composites of LWRP sludge. At the

**Table 6-3. Tritium in sanitary sewer effluents, LLNL and LWRP, 2001**

Monitoring results			
	LLNL		LWRP
	Daily	Monthly average	Weekly
Maximum (Bq/mL)	0.370 ± 0.012 ^(a)	0.047 ^(b)	0.0097 ^(c)
Median (Bq/mL)	0.002	0.002	−0.0006
IQR ^(d) (Bq/mL)	0.005	0.001	0.004
LLNL annual total (GBq)	4.9		
Discharge limits for LLNL effluent			
	Discharge limit	Monitoring results as percentage of limit	
		Maximum	Median
LWRP permit daily (Bq/mL)	12	3.08	0.014
DOE 5400.5 monthly (DCG) ^(e) (Bq/mL)	370	0.013 ^(f)	0.0005 ^(f)
10 CFR 20 annual total (GBq)	185	2.6	

a This daily result is for a March sample; the detection limit for the analysis was 0.01 Bq/mL. See the Data Supplement, Chapter 6, for all daily results.

b This is the monthly average for March. All monthly averages above limit of sensitivity (LOS) are plotted in **Figure 6-2**.

c This is a weekly result for a June sample. The result was not above the detection limit (0.010 Bq/mL) for the analysis. None of the LWRP weekly monitoring results were greater than the detection limits for the analyses; a detection limit is the smallest concentration of radioactive material that can be detected with a large degree of confidence. (See Chapter 14.) The detection limits ranged from 0.008 to 0.012 Bq/mL. See the Data Supplement, Chapter 6, for all weekly results.

d IQR = Interquartile range.

e DCG = Derived Concentration Guide

f Monitoring results as a percentage of limit are calculated using LLNL monthly average results and the DOE annualized discharge limit.

bottom of the table, the total annual activity released is given by radioisotope. Also included in the table are fractions of DOE limits, discussed in the “[Environmental Impact](#)” section.

Figure 6-3 shows the average monthly plutonium and cesium concentrations in sewage since 1992. For 2001, the annual mean concentration of cesium-137 was 3.2×10^{-6} Bq/mL (8.7×10^{-5} pCi/mL); the annual mean concentration of plutonium-239 was 3.5×10^{-7} Bq/mL (9.5×10^{-6} pCi/mL).

Environmental Impact

During 2001, no inadvertent discharges exceeded any discharge limits for release of radioactive materials to the sanitary sewer system.

In 1999, the Work Smart Standards (WSS) developed for LLNL became effective. Included in the WSS are the standards selected for sanitary sewer discharges. For radioactive material releases, complementary (rather than redundant) sections

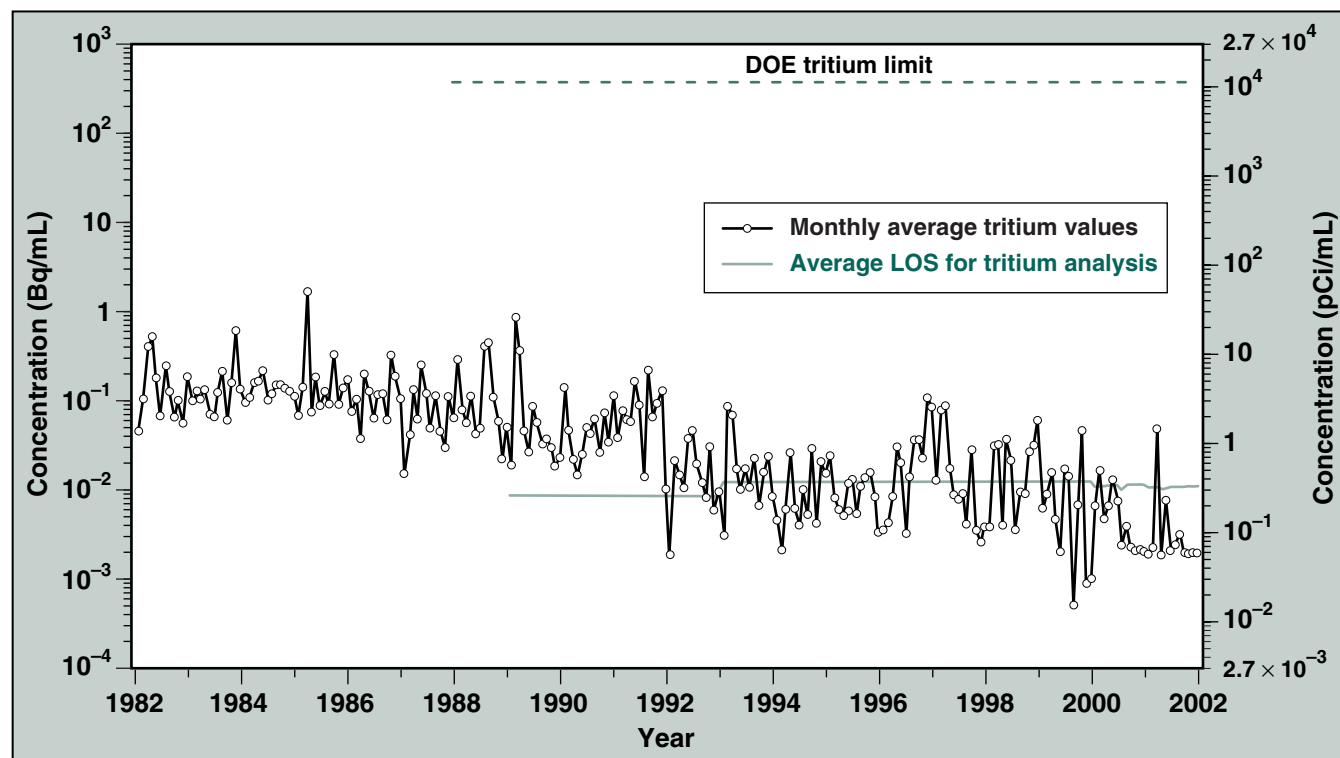


Figure 6-2. Historical trend in tritium concentration in LLNL sewage

from DOE Order 5400.5 and Title 10 of the Code of Federal Regulations, Part 20, are both part of the standards.

From DOE Order 5400.5, the WSS for sanitary sewer discharges include the criteria DOE established for the application of best available technology to protect public health and minimize degradation of the environment. These criteria (the Derived Concentration Guides, or DCGs) limit the concentration of each radionuclide discharged to publicly owned treatment works. If a measurement of the monthly average concentration of a radioisotope exceeds its specific concentration limit, LLNL is required to improve discharge control measures until concentrations are again below the DOE

limits. [Table 6-3](#) and [Table 6-4](#) include the DCGs for the specific radioisotopes of most interest at LLNL.

The median monthly average concentration of tritium in LLNL sanitary sewer effluent was 0.0005% of the DOE DCG, and the maximum monthly average concentration of tritium was 0.013% of the DCG (see [Table 6-3](#)).

The annual average concentration of cesium-137 was 0.00057% of the DOE DCG; and the annual average plutonium-239 concentration was 0.000095% of the DOE DCG. These results are shown at the bottom of [Table 6-4](#).



Table 6-4. Cesium and plutonium in sanitary sewer effluents, LLNL and LWRP, 2001

Month	¹³⁷ Cs (μBq/mL)				²³⁹ Pu (nBq/mL)				²³⁹ Pu (mBq/dry g)	
	LLNL		LWRP		LLNL		LWRP		LWRP sludge ^(a)	
	Radio-activity	MDC	Radio-activity	MDC	Radio-activity	MDC	Radio-activity	MDC	Radio-activity	MDC
Jan	−0.81 ± 2.8	2.48	−0.818 ± 2.52	2.22	95.1 ± 23.2	9.58	5 ± 5.62	7.03	0.183 ± 0.016	0.002
Feb	8.03 ± 1.84	2.65	−0.559 ± 2.86	2.49	1890 ± 125	9.62	1.67 ± 5.4	8.84		
Mar	3.34 ± 2.65	2.5	−0.866 ± 2.42	2.08	381 ± 54	12.3	1.62 ± 4.37	8.18		
Apr	0.318 ± 2.63	2.36	1.13 ± 2.62	2.42	195 ± 33.4	6.81	8.62 ± 7.73	8.88		
May	1.27 ± 0.577	1.38	−0.67 ± 2.61	2.26	492 ± 54.4	9.77	−0.981 ± 7.59	11.8	0.525 ± 0.051	0.007
Jun	1.55 ± 2.82	2.62	0.803 ± 2.52	2.29	319 ± 29.5	7.33	−3.69 ± 10.6	13.4		
Jul	−0.0219 ± 2.8	2.48	0.0829 ± 2.32	2.06	105 ± 23	11.1	−0.836 ± 4.22	9.73		
Aug	−1.67 ± 2.65	2.21	0.0266 ± 2.56	2.28	171 ± 35.3	17.9	−3.1 ± 3.53	10.8		
Sep	1.62 ± 3.85	3.48	1.19 ± 3.65	3.29	174 ± 31.5	12.6	0.186 ± 6.22	13	0.243 ± 0.028	0.007
Oct	3.64 ± 3.85	3.57	−0.64 ± 3.3	2.88	136 ± 26	11.4	2.35 ± 5	8.84		
Nov	−0.84 ± 3.81	3.32	1.6 ± 3.59	3.25	92.5 ± 27	11.8	0.847 ± 3.92	7.44		
Dec	1.7 ± 3.77	3.45	0.777 ± 3.54	3.17	185 ± 35.1	9.92	2.15 ± 2.98	4.22		
Median	1.4		0.1		353		−1.23		0.27	
IQR ^(b)	2.33		1.53		206		3.07		0.13	
	pCi/mL ^(c)								pCi/dry g ^(c)	
Median	3.8 × 10 ^{−5}		1.5 × 10 ^{−6}		4.8 × 10 ^{−6}		−3.3 × 10 ^{−8}		0.0073	
IQR ^(b)	6.3 × 10 ^{−5}		4.1 × 10 ^{−5}		5.6 × 10 ^{−6}		8.3 × 10 ^{−8}		0.0034	
	Annual LLNL total discharges by radioisotope									
	¹³⁷ Cs				²³⁹ Pu					
Bq/y	1.0 × 10 ⁶				1.1 × 10 ⁵					
Ci/y	2.8 × 10 ^{−5}				3.0 × 10 ^{−6}					
	Fraction of limit ^(d)									
DOE 5400.5 DCG ^(e)	5.7 × 10 ^{−6}				9.5 × 10 ^{−7}					

Note: Results in this table are reported as radioactivity (the measured concentration and a $\pm 2\sigma$ counting uncertainty) along with the detection limit or minimum detectable concentration (MDC). A measure concentration exhibiting a 2σ counting uncertainty greater than or equal to 100% is considered to be a nondetection. See Chapter 14.

a Sludge from LWRP digesters is dried before analysis. The resulting data indicate the plutonium concentration of the sludge prepared by LWRP workers for disposal at the Vasco Road Landfill in Alameda County.

b IQR= Interquartile range

c 1 Ci = 3.7×10^{10} Bq

d Fraction of limit calculations are based on the annual total discharge for a given isotope and the corresponding concentration-based limit (0.56 and 0.37 Bq/mL for cesium-137 and plutonium-239, respectively) multiplied by the annual volume of Livermore site effluent.

e DCG = Derived Concentration Guide

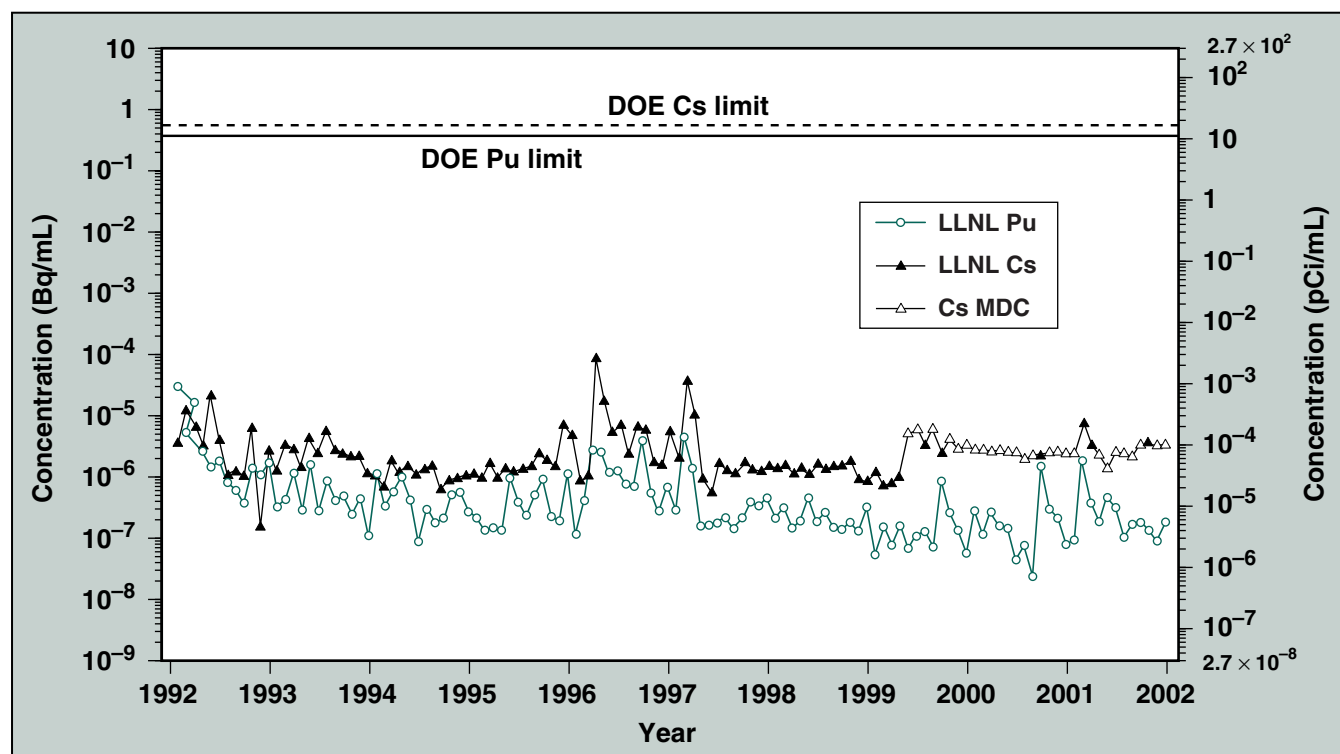


Figure 6-3. Historical trends in average monthly plutonium and cesium concentrations in LLNL sewage

From 10 CFR 20, the numerical discharge limits for sanitary sewer discharges in the WSS include the annual discharge limits for radioactivity: 185 GBq (5 Ci) of tritium, 37 GBq (1 Ci) of carbon-14, and 37 GBq (1 Ci) of all other radionuclides combined.

The 10 CFR 20 limit on total tritium activity dischargeable during a single year (185 GBq) overrides the DOE Order 5400.5 concentration-based limit for tritium for facilities such as LLNL that generate wastewater in large volumes. In 2001, the total LLNL tritium release was 2.6% of the 10 CFR 20 limit. Total LLNL releases (see [Table 6-2](#)), in the form of alpha and beta emitters (excluding tritium), were 0.87% of the corresponding 10 CFR 20 limit.

In addition to the DOE average concentration discharge limit for tritium and the 10 CFR 20 annual total discharge limit for tritium, the LWRP established in 1999 an effluent concentration discharge limit for LLNL daily releases of tritium. This limit is more stringent than the DOE discharge limit: it is a factor of 30 smaller and applies to a daily rather than an annualized concentration. The maximum daily concentration for tritium in 2001 was 3.08% of the permit discharge limit. [Table 6-3](#) shows this result and the daily effluent discharge limit for tritium. Both maximum daily and maximum monthly values are for the month of March. The values are higher than the 2000 values. Tritium releases that were well below DOE limits and approved by EPD and LWRP in the month of March account for these higher values.



LLNL also compares annual discharges with historical values to evaluate the effectiveness of ongoing discharge control programs. **Table 6-5** summarizes the radioactivity in liquid effluent released over the past 10 years. During 2001, a total of 4.9 GBq (0.13 Ci) of tritium was discharged to the sanitary sewer, an amount that is well within environmental protection standards and is comparable to the amounts reported since 1991. Moreover, the total tritium released by LLNL in 2001 continues the 1992 to 2000 trend of significantly smaller releases than those in the years prior to 1992.

Table 6-5. Radioactive liquid effluent releases from the Livermore site, 1992–2001

Year	Liquid effluent (GBq)	
	^3H	^{239}Pu
1992	8	1.9×10^{-3}
1993	13	2.6×10^{-4}
1994	6.9	1.9×10^{-4}
1995	6.0	1.2×10^{-4}
1996	12 ^(a)	4.2×10^{-4}
1997	9.1	2.1×10^{-4}
1998	10	7.7×10^{-5}
1999	7.1	6.8×10^{-5}
2000	5.0	9.6×10^{-5}
2001	4.9	1.1×10^{-4}

^a In 1995, Sandia/California ceased all tritium facility operations. Therefore, the annual tritium totals beginning with the 1996 value do not include contributions from Sandia/California.

Figure 6-3 summarizes the plutonium-239 monitoring data over the past 10 years. The historical levels observed since 1992 average 1 $\mu\text{Bq/mL}$ (3×10^{-5} pCi/mL). These historical levels generally are three-millionths (0.000003) of the DOE DCG for plutonium-239. The greatest part of the pluto-

nium discharged in LLNL effluent is ultimately concentrated in LWRP sludge. The median plutonium concentration observed in 2001 sludge (**Table 6-4**), 0.27 mBq/dry g, is approximately 350 times lower than the EPA preliminary remediation goal for residential soil (93 mBq/dry g) and is nearly 1400 times lower than the remediation goal for industrial or commercial soil (370 mBq/dry g).

As first discussed in the *Environmental Report 1991* (Gallegos et al. 1992), plutonium and cesium concentrations were slightly elevated during 1991 and 1992 over the lowest values seen historically. As was established in 1991, the overall upward trend was related to sewer cleaning with new, more-effective equipment. The concentrations in 1996 and the first quarter of 1997 were also slightly higher than the lowest values seen historically, although slightly lower than those of 1990 through 1992. In fact, the cyclic nature of the data in **Figure 6-3** suggests a potential frequency relationship in LLNL sewer lines for radionuclide buildup and subsequent liberation by line cleaning. The higher plutonium and cesium concentrations are all well below applicable DOE DCGs. In general, the plutonium and cesium concentrations for 2001 are comparable to the lowest values seen historically, and are well below the applicable DOE DCGs. (Note that because MDC values for cesium analysis increased in May 1999, most analytical results are below their respective MDCs; see **Table 6-4**.)

Nonradioactive Pollutants in Sewage

Monitoring Results

Table 6-6 presents monthly average concentrations for all regulated metals in LLNL's sanitary sewer effluent for 2001. The averages were obtained by a flow-proportional weighting of the analytical results for the weekly composite samples collected each month. Each result was weighted by

Table 6-6. Average monthly results for regulated metals in LLNL sanitary sewer effluent (mg/L), 2001

Month	Ag	As	Cd	Cr	Cu	Hg	Ni	Pb	Zn
Jan	<0.010	0.0034	<0.0050	0.019	0.083	0.00020	0.0097	0.0063	0.18
Feb	<0.010	0.0052	<0.0050	0.014	0.12	0.00024	0.0069	0.0083	0.29
Mar	0.010	0.0031	<0.0050	0.020	0.13	0.00024	0.0074	0.019	0.36
Apr	0.016	0.0038	<0.0050	0.018	0.15	0.00031	0.0082	0.026	0.44
May	0.010	0.0051	<0.0050	0.031	0.23	0.00041	0.0069	0.051	0.54
Jun	0.010	0.0047	<0.0050	0.028	0.27	0.00048	0.0095	0.026	0.47
Jul	<0.010	0.0039	<0.0050	0.025	0.30	0.00041	0.0075	0.034	0.43
Aug	<0.010	0.0056	<0.0050	0.020	0.25	0.00031	0.0087	0.041	0.36
Sep	<0.010	0.0036	<0.0050	0.021	0.26	0.00042	0.0082	0.021	0.34
Oct	0.017	0.0030	<0.0050	0.014	0.14	0.00029	0.0066	0.012	0.25
Nov	<0.010	0.0030	<0.0050	0.011	0.15	0.00022	0.0053	0.014	0.28
Dec	<0.010	0.0045	<0.0050	0.014	0.14	0.00027	0.0069	0.015	0.33
Median	<0.010	0.0038	<0.0050	0.019	0.15	0.00030	0.0075	0.020	0.35
IQR ^(a)	— ^(b)	0.0014	— ^(b)	0.0081	0.11	0.00017	0.0014	0.015	0.15
EPL ^(c)	0.2	0.06	0.14	0.62	1	0.01	0.61	0.2	3.0
Median fraction of EPL	<0.05	0.06	<0.04	0.03	0.15	0.03	0.01	0.10	0.12

Note: Monthly values are presented with less-than signs when all weekly composite sample results for the month are below the detectable concentration.

a IQR = Interquartile range

b Because of the large number of nondetects, the interquartile range cannot be calculated for these metals. See Chapter 14.

c Effluent pollutant limit (LLNL Wastewater Discharge Permit 2000–2001 and 2001–2002)

the total flow volume for the period during which the sample was collected. The results are generally typical of the values seen from 1994 to 2000; however, the median concentration values in 2001 are either less than, or equal to, the corresponding 2000 values for the nine regulated metals.

As discussed in the “[Environmental Impact](#)” section, no median concentration showed an increase above last year’s value. [Figure 6-4](#) presents historical trends for the monthly 24-hour composite sample results from 1994 through 2001 for eight of the nine regulated metals; cadmium is not presented because this metal is typically not detected. Although well below their respective

effluent pollutant limits (EPLs), both arsenic and lead show an occasional elevated concentration in 2001, and copper continues to show average concentrations above those observed in the mid-1990s. The other metals have no discernible trends in their concentrations.

The concentrations measured in the routine analysis of LLNL sewage samples collected once a week (seven-day composite sample) and once a month (24-hour composite samples) are presented for eight of nine regulated metals as a percentage of the corresponding EPL in [Figure 6-5](#); cadmium results are not presented because the metal was not detected, above the practical quantitation limit

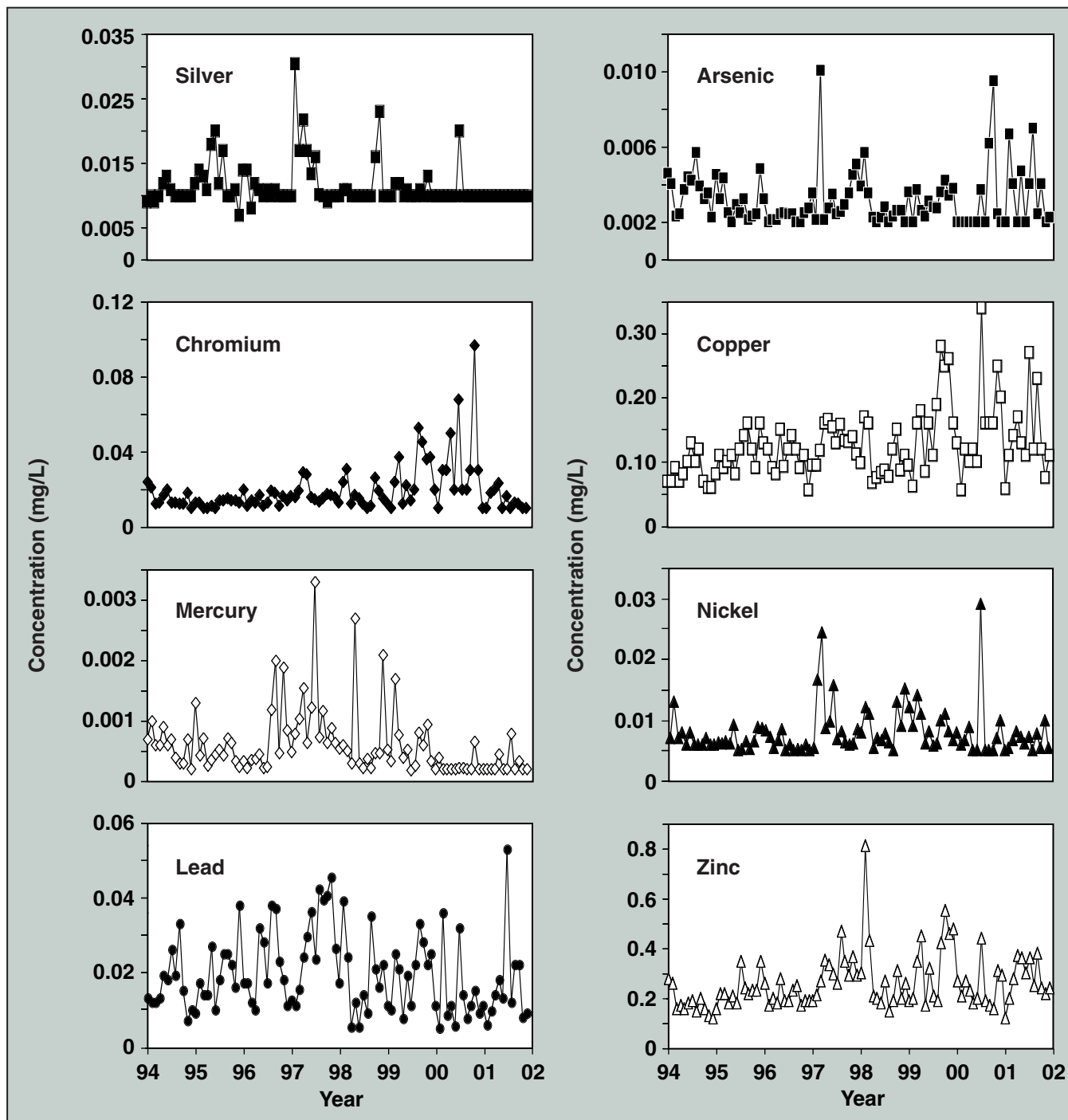


Figure 6-4. Monthly 24-hour composite sample concentrations for eight of the nine regulated metals in LLNL sanitary sewer effluent showing trends from 1994 to 2001

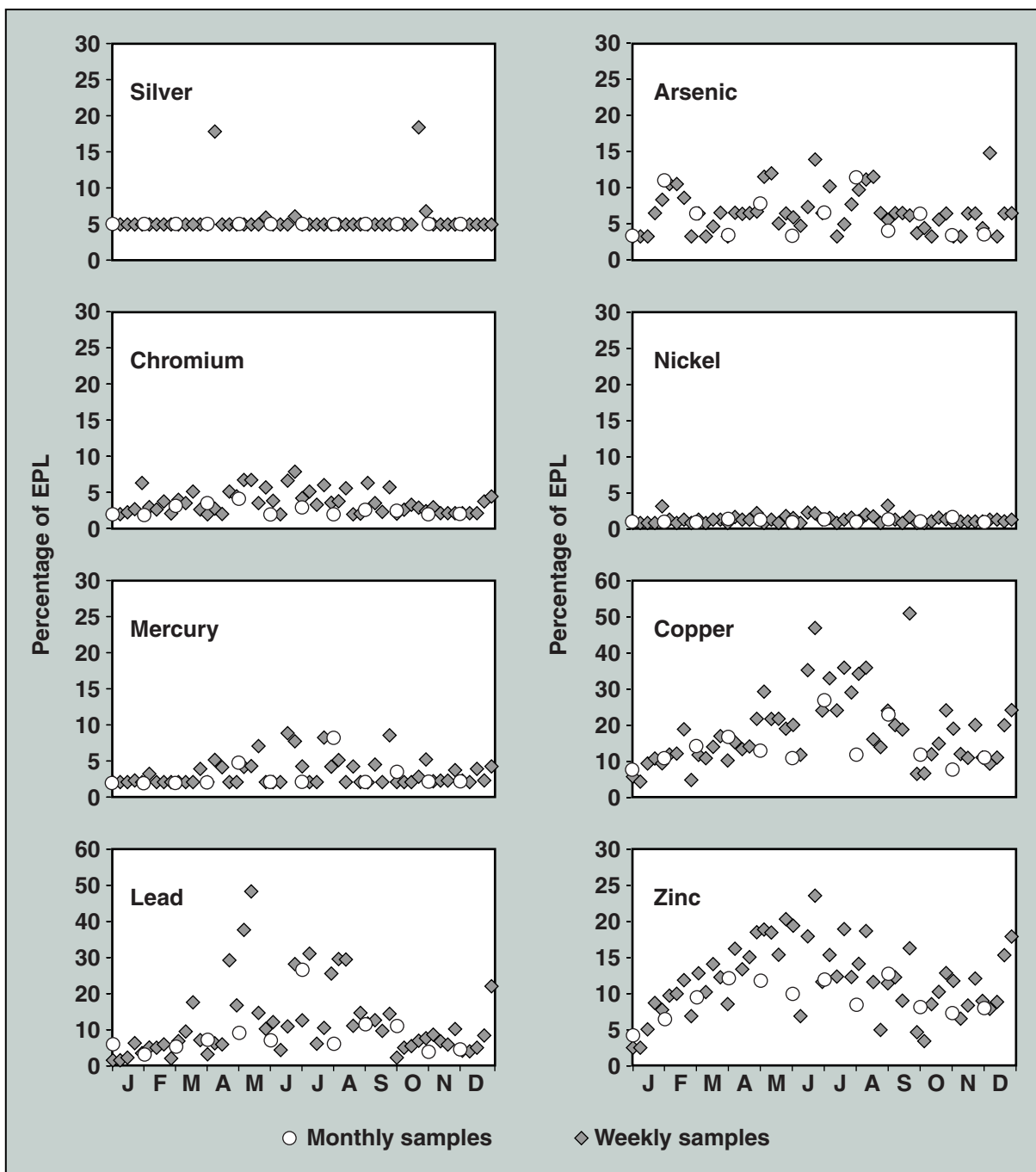


Figure 6-5. Results as percentages of effluent pollutant limits (EPLs) for eight of the nine regulated metals in LLNL sewage, 2001



(PQL) of 0.005 mg/L, in any of the weekly or monthly samples. The EPL is equal to the maximum pollutant concentration allowed per 24-hour composite sample, as specified by the LLNL wastewater discharge permit. When a weekly sample concentration is at or above 50% of its EPL, all daily (24-hour composite) samples collected in the SMS corresponding to the weekly sample period must be analyzed to determine if any of their concentrations are above the EPL.

Figure 6-5 shows no monthly sample metal concentration above 50% of its EPL; the highest monthly concentration reported was 27% of the respective EPL for both the July copper and July lead values. As discussed further in the “**Environmental Impact**” section, **Figure 6-5** also shows three weekly samples (one lead and two copper) at or near the specified action level.

Detections of anions, metals, and organic compounds and summary data concerning other physical and chemical characteristics of the sanitary sewer effluent are provided in **Table 6-7**. (All analytical results are provided in the Data Supplement, Table 6-7.) Although monthly (24-hour) composite samples were analyzed for carbonate alkalinity (as CaCO_3), hydroxide alkalinity (as CaCO_3), nitrate (as N), nitrate (as NO_3), beryllium, and selenium, these analytes were not detected in any sample acquired during 2001, and so are not presented in **Table 6-7**. Similarly, analytes not detected in any of the 2001 monthly grab samples are not shown in **Table 6-7**. These monthly monitoring results for physical and chemical characteristics of the LLNL sanitary sewer effluent are typical of those seen in previous years. See the “**Environmental Impact**” section for further discussion.

Environmental Impact

Table 6-6 presents monthly average concentrations and summary statistics for all regulated metals

monitored in LLNL’s sanitary sewer effluent. At the bottom of the table, the annual median concentration for each metal is shown and compared with the discharge limit. In 2001, the monthly average median concentration values have decreased from the corresponding 2000 values for seven of the nine regulated metals (As, Cr, Cu, Hg, Ni, Pb, and Zn). The two regulated metals not routinely detected in LLNL effluent, silver and cadmium, had median concentration values that remained unchanged at the PQL. These results are consistent with the weekly composite median values shown in Data Supplement Table 6-5. Monthly average median concentrations were less than one-tenth of the discharge limits for all but copper, lead, and zinc, which were at 15%, 10%, and 12%, respectively.

Although median values of metal concentrations have decreased, or remained at the PQL in the case of silver and cadmium, and all the monthly (24-hour) composite sample results for 2001 were less than 50% of the corresponding discharge limits, three weekly samples were identified for additional analyses based on metal concentrations at or near the action limit. These investigations examined a weekly sample in May (for lead at 49% of the EPL) and weekly samples in June and September (for copper at 47% and 51% of the EPL, respectively). The daily samples that correspond to the appropriate 7-day composite sampling periods were submitted to an off-site contract analytical laboratory for analysis. Lead concentrations in daily samples from the week of May 10–16 were reported as: 0.008 mg/L, 0.16 mg/L, 1.4 mg/L, 0.03 mg/L, 0.01 mg/L, 0.061 mg/L, and 0.021 mg/L, respectively. These results show an exceedance (1.4 mg/L) of the 0.2 mg/L permitted discharge limit for lead in the May 12, 2001, sample (representing effluent collected during the prior 24-hour period). In July 2001, the LWRP issued an NOV as a result of this exceedance of the EPL for lead. No corrective action was suggested or required, because LLNL had returned

Table 6-7. Monthly monitoring results for physical and chemical characteristics of the LLNL sanitary sewer effluent, 2001^(a)

	Detection frequency ^(b)	Minimum	Maximum	Median	IQR ^(c)
24-hour composite sample parameter (mg/L)					
Alkalinity					
Bicarbonate alkalinity (as CaCO ₃)	12/12	173	245	231	20
Total alkalinity (as CaCO ₃)	12/12	173	245	231	20
Anions					
Bromide	10/12	<0.1	1.1	0.4	0.45
Chloride	12/12	27	104	46	9
Fluoride	10/12	<0.050	0.92	0.125	0.11
Nitrate plus Nitrite (as N)	2/12	<0.1	1	1	— ^(d)
Nitrite (as N)	7/12	<0.02	0.23	0.02	0.006
Nitrite (as NO ₂)	7/12	<0.065	0.76	0.066	0.021
Orthophosphate	12/12	14.7	25	20	1.9
Sulfate	12/12	8.4	27	11.5	1.8
Nutrients					
Ammonia nitrogen (as N)	12/12	36	59	48	6
Total Kjeldahl nitrogen	12/12	35	94	70	8
Total phosphorus (as P)	12/12	6.2	13	10.5	2.6
Oxygen demand					
Biochemical oxygen demand	12/12	100	810	333	180
Chemical oxygen demand	12/12	145	1780	602	516
Solids					
Settleable solids	12/12	4	90	40	28
Total dissolved solids	12/12	165	413	256	28
Total suspended solids	12/12	88	650	385	255
Volatile solids	12/12	140	913	480	208
Total metals					
Calcium	12/12	9.3	20	15.5	3.3
Magnesium	12/12	1.7	5.1	3.05	0.65
Potassium	12/12	15	24	22	2.3
Sodium	12/12	23	73	37	4
Total organic carbon	12/12	38	73	57	11
Tributyltin (ng/L)^(f)	2/2	14	19	16.5	— ^(d)



Table 6-7. Monthly monitoring results for physical and chemical characteristics of the LLNL sanitary sewer effluent, 2001^(a) (continued)

	Detection frequency ^(b)	Minimum	Maximum	Median	IQR ^(c)
Grab sample parameter					
Semivolatile organic compounds (µg/L)					
Benzoic acid	4/12	<10	72	15	— ^(d)
Benzyl alcohol	10/12	<2	71	7.4	8.2
Bis(2-ethylhexyl)phthalate ^(e)	10/12	<5	94	11.5	6.0
Diethylphthalate ^(e)	12/12	2.7	31	9.5	5.5
m- and p- Cresol	9/12	<2	35	9.2	13.2
Phenol ^(e)	4/12	<2	17	2	— ^(d)
Pyrene ^(e)	1/12	<2	3	2	— ^(d)
Total cyanide (mg/L)^(f)	0/2 ^(g)	<0.02	<0.02	<0.02	— ^(d)
Oil and grease (mg/L)^(f)	2/2	18	20	19	— ^(d)
Volatile organic compounds (µg/L)					
1,2-Dichloroethene ^(e)	1/12	<0.50	0.6	0.5	— ^(d)
1,4-Dichlorobenzene ^(e)	4/12	<0.50	3.4	0.5	— ^(d)
Acetone	12/12	98	480	225	175
Benzene ^(e)	1/12	<0.50	1.3	0.5	— ^(d)
Bromodichloromethane ^(e)	2/12	<0.50	3.5	0.5	— ^(d)
Bromoform ^(e)	2/12	<0.50	3.4	0.5	— ^(d)
Chloroform ^(e)	12/12	7	20	9.2	3.2
Dibromochloromethane ^(e)	1/12	<0.50	4.4	0.5	— ^(d)
Freon 113	1/12	<0.50	1.2	0.5	— ^(d)
Methylene chloride ^(e)	1/12	<1	1.6	1	— ^(d)
Napthalene ^(e)	1/12	<0.50	0.79	0.5	— ^(d)
Styrene	2/12	<0.50	9.3	0.5	— ^(d)
Toluene ^(e)	7/12	<0.50	1.4	0.58	0.31

a The monthly sample results plotted in [Figure 6-5](#) and nondetected values reported in the Data Supplement, Chapter 6, are not reported in this table.

b The number of times an analyte was positively identified, followed by the number of samples that were analyzed (generally 12, one sample for each month of the year).

c IQR = Interquartile range

d When the detection frequency is less than or equal to 50%, there is no range, or there are fewer than four results for a sample parameter, then the interquartile range is omitted.

e Priority toxic pollutant parameter used in assessing compliance with the total toxic organic (TTO) permit limit of 1 mg/L (1000 µg/L) issued by the Livermore Water Reclamation Plant.

f Sampling for this parameter is required on a semiannual rather than a monthly basis.

g Although cyanide was not detected in either of the semiannual samples, the results are reported in this table to demonstrate compliance with the cyanide permit limit of 0.04 mg/L.

to compliance the following day and sufficient measures had been taken to investigate this inadvertent discharge. The results of similar analyses showed no copper concentration greater than 0.29 mg/L (29% of the EPL) in the June or September daily samples. Although each of these incidents was reported to the LWRP, none represented a threat to the integrity of the LWRP operations.

Table 6-7 presents summary results and statistics for monthly monitoring of physical and chemical characteristics of LLNL's sanitary sewer effluent. The results are generally similar to typical values seen in previous years for the two regulated parameters (cyanide and total toxic organics [TTO]) and all other nonregulated parameters. Cyanide was not detected in either of the required semiannual samples and the monthly TTO values ranged from less than 0.010 mg/L to 0.045 mg/L (median was 0.028 mg/L), well below the TTO permit limit of 1.0 mg/L. In addition to the organic compounds regulated under the TTO standard, six non-regulated organics were also detected in LLNL's sanitary sewer effluent: three volatile organic compounds (acetone, Freon 113, and styrene) and three semivolatile organic compounds (benzoic acid, benzyl alcohol, and 3- & 4-methylphenol).

In 2001, the SMS continuous monitoring system detected three inadvertent discharges outside the permitted pH range of 5 to 10. Two of the discharges were below pH 5 and one was above pH 10; all three discharges were captured in the SDF. For comparison, 2, 4, and 2 diversions occurred in 2000, 1999, and 1998, respectively.

Monitoring results for 2001 reflect an outstanding year for LLNL's sewerable water discharge control program and Livermore site personnel. As discussed above, LLNL's continuous monitoring system detected and diverted three inadvertent pH discharges. The one permit exceedance resulted from an elevated lead concentration in the May 12, 2001 daily effluent sample. Overall, LLNL achieved greater than 99% compliance with the provisions of its wastewater discharge permit.